

Appendix J

Monitoring

Table of Contents

Monitoring Project Success	J-3
Monitoring Mitigation Activities	J-3
Monitoring-Plan Development	J-4
Statement of Objectives	J-4
Project Objectives	J-4
Mitigation Objectives (Targets)	J-5
Monitoring Objectives	J-5
Monitoring Parameters	J-5
Success Criteria	J-5
Measurable Attributes	J-6
Monitoring Intensity	J-7
Monitoring Protocol	J-7
Geographic Extent of Monitoring	J-8
Monitoring Duration and Frequency	J-8
Collecting and Reporting of Monitoring Data	J-9
Baseline Data	J-9
Reporting Monitoring Data	J-9
Monitoring-Plan Components	J-10
Monitoring Experimental Techniques	J-11
References	J-11



Appendix J

Monitoring

This appendix is intended to provide general guidelines for developing streambank-protection monitoring plans. Monitoring is defined as the collection and assessment of repeated observations or measurements over time to evaluate the performance and impacts of bank-protection treatments. This appendix provides a framework for monitoring activities that integrates riparian and fluvial processes with assessments of the physical integrity and performance of streambank-protection treatments.

MONITORING PROJECT SUCCESS

Monitoring activities enable property owners, scientists and regulators to observe bank-protection performance under a range of changing environmental factors, including flooding or drought, channel shifts and erosion, and biologic factors such as beaver activity or the effects of animal grazing. In addition, a comprehensive monitoring plan creates a foundation for maintenance activities that ensure project goals are met and that the project continues to perform as intended over time. And, finally, monitoring allows those engaged in protecting or regulating the protection of streambanks to identify ways to improve and refine bank-protection techniques.

MONITORING MITIGATION ACTIVITIES

Monitoring activities may also be necessary to demonstrate successful habitat maintenance. Consequently, monitoring mitigation activities and impacts associated with bank-protection projects will be a requirement of most projects. The objective of monitoring habitat is to document impacts to habitat, and success of avoidance, minimization and compensatory mitigation activities. However, the discussion of specific mitigation and habitat-monitoring activities is beyond the scope of this document. For further discussion and direction in mitigation monitoring for habitat, refer to *Inventory and Monitoring of Salmon Habitat in the Pacific Northwest -Directory and Synthesis of Protocols and Management/Research and Volunteers in Washington, Oregon, Idaho, Montana, and British Columbia*.¹

This appendix will introduce and discuss the key components of monitoring streambank-protection projects. Additional and specific information on monitoring streambank-protection projects can be found in Chapter 6, *Techniques*, where each technique description contains a discussion on monitoring considerations.

MONITORING-PLAN DEVELOPMENT

Developing a monitoring plan includes determining objectives, identifying parameters to be measured, establishing a monitoring protocol, collecting data and reporting results. These steps are first outlined and subsequently detailed below.

1. Statement of objectives:
 - project objectives
 - mitigation objectives (targets), and
 - monitoring objectives.
2. Identification of monitoring parameters:
 - determination of success criteria,
 - measurable attributes, and
 - determination of monitoring intensity.
3. Establishment of monitoring protocol:
 - geographic extent of monitoring, and
 - determination of monitoring duration and frequency.
4. Collection and reporting of monitoring data:
 - baseline data, and
 - reporting of monitoring data.

Statement of Objectives

Project and mitigation objectives drive the monitoring process and ultimately define project success. Project objectives should be clearly stated in the project design and understood by all entities involved. Mitigation objectives, or targets, must be provided for all projects requiring compensatory mitigation. Criteria developed for bank-protection design and mitigation design will reflect the project objectives and may be useful in some circumstances as a basis for developing monitoring parameters and attributes (see Chapter 4, *Considerations for a Solution*).

Project Objectives

The fundamental purpose of monitoring is to evaluate the success of a streambank-protection project with respect to the objectives of that project. Project objectives are generally oriented toward protecting a streambank or features landward of the streambank from erosion. Project objectives are generally framed within the context of acceptable risk and may include varying spatial and temporal scales, which may differ significantly among projects. Acceptable risk may include protection up to a given discharge event, after which bank failure does not necessarily represent failure with respect to objectives. Streambank-protection objectives are discussed in more detail in Chapter 4.

Mitigation Objectives (Targets)

Common compensatory-mitigation targets are:

- to improve factors within the watershed that limit fish production,
- to restore properly functioning habitat,
- to replicate natural conditions, and
- to restore or replace preproject conditions.

As discussed in Chapter 4, mitigation targets vary in scope from an entire watershed down to specific project site conditions. Targets vary in substance according to the objectives and authorities of agencies that permit work in stream channels. The habitat-mitigation monitoring plan must be in keeping with the initial, mitigation needs assessment and must reflect the original mitigation target. It is likely that the habitat-mitigation objective will drive the entire habitat-monitoring plan.

Monitoring Objectives

Monitoring objectives are used to evaluate project performance in relation to bank-protection objectives, mitigation objectives and any corollary objectives, including those for habitat. Additionally, where an experimental technique is applied, monitoring objectives will include evaluation of how closely aligned the project design is to the original design criteria.

Monitoring Parameters

Monitoring parameters are components of a bank-protection project that need to be assessed to evaluate whether project objectives have been met. A project consisting of just riprap protection may have a small set of monitoring parameters, such as the integrity of installed riprap, channel cross-section stability, and upstream/downstream bank conditions. Any mitigation for such a project will also require monitoring parameters. Monitoring parameters for an experimental project using engineered log jams may include stability/integrity of the structure, bank erosion adjacent to the structure, bed scour, thalweg realignment, sediment deposition, woody debris accumulation, documentation of high-flow hydraulics, habitat use and plant survival. Once identified, these parameters serve as a first step in developing a suite of measurable attributes, measurement techniques and success criteria that together comprise the core of the monitoring plan.

Success Criteria

Success criteria are specific, predetermined thresholds of performance for the measurable attributes of a bank-protection project. They are not the same as monitoring objectives. In many instances, success criteria will be the same as design criteria, though there may be additional criteria for measuring success included. Success criteria should be developed for the protection project as well as any associated mitigation.

Success criteria are important to monitoring because they define acceptable performance thresholds for initiating project maintenance. Typically, if a success criterion is not achieved, a maintenance activity such as replanting or repositioning of rock may be required. Success

criteria are not necessary or possible for all monitoring attributes. For example, photography from fixed photo points can be used as a monitoring technique for qualitative attributes that are not linked to definitive criteria for success. In this application, monitoring can be performed for qualitative evaluation as opposed to distinct success evaluation.

Measurable Attributes

It is important to identify the measurable attributes and evaluation techniques for each monitoring parameter. The suggested process consists of selecting the measurable attributes that most effectively characterize each parameter; followed by the most effective method to measure, or evaluate, that attribute. For example, bank slope and shape is a measurable attribute of the success of a bank protection treatment. A cross-section survey is an effective measurement tool for measuring this attribute and provides more detailed, quantitative data than a written description with photos. Similarly, plant survival is a measurable attribute for vegetation establishment and can be measured by a physical count of live stems and/or aerial foliage cover.

To understand project success, monitoring must be done relative to preproject conditions. Attributes and measurement techniques applied to pre- and postproject implementation must be consistent so results can be compared and are therefore meaningful.

Table J-1 includes some examples of measurable attributes and evaluation techniques for selected monitoring parameters. For further detail on monitoring parameters and measurable attributes, refer to each individual technique described in Chapter 6.

Monitoring Parameter	Measurable Attribute	Evaluation Technique
Bank protection	Cross section shape Channel planform	Cross section survey Aerial photographs Channel alignment site survey
Upstream and downstream geomorphic impacts	Cross section shape and channel planform	Cross section survey Aerial photographs Channel alignment site survey
High-flow hydraulics	Local flow patterns Flow angle of approach to bank Zones of active erosion Flow history, including peak-flow return intervals Occurrence of debris jams	Video Video Photo documentation, survey Hydrologic analysis Photo documentation, survey
Fish habitat	Rearing habitat (quantity/quality) Spawning habitat (quantity/quality) Cover (quantity/quality)	Stream temperature Bed-material composition Water depth and velocity Percent cover, shading Habitat mapping Population assessments for fish and invertebrates
Vegetation establishment	Plant-survival rate Plant diversity Natural-recruitment patterns Uniformity of aerial cover Bird and wildlife presence	Percent vegetative cover Species composition, density Size distribution Age/class distribution

Table J-1. Sample monitoring parameters, listed with measurable attributes and potential evaluation techniques applicable to streambank-protection projects.²

Monitoring Intensity

Monitoring intensity refers to the level of detail required in the monitoring process, regardless of whether the process is qualitative or quantitative.

Qualitative monitoring tends to be descriptive and often consists of visual observations, the use of broad descriptive categories (good/fair/poor; present/absent, or unstable/stable) or the use of permanent recording methods such as photo points.⁴ On the other hand, quantitative monitoring is objective and consists of a series of discreet, replicable measurements that are usually analyzed statistically and can be more easily related to design criteria and/or success criteria.

Qualitative monitoring is relatively inexpensive and allows for rapid assessment of relatively large areas, making it effective for general assessments of bank-protection integrity and vegetation. However, qualitative monitoring does not produce results that can be easily compared. Despite this limitation, qualitative monitoring is effective for inspection of the integrity of most structural bank protection techniques, including toe treatments, fabric-covered upper banks, woody-debris structures and instream channel modifications. Additionally, qualitative monitoring allows for recognition of nonquantifiable attributes, such as cracks and soil loss, which may be early signs of imminent bank failure.

Quantitative monitoring provides numerical data that can be statistically evaluated, but it tends to be relatively tedious and expensive. With good attention to detail, a considerable amount of information can be collected using a quantitative approach. Appropriate applications of quantitative monitoring include projects in which temporal changes in vegetation cover or channel cross-section form or grade are expected and need to be accurately assessed. In addition, mitigation components of streambank projects often require quantitative monitoring approaches to meet agency-mandated success criteria.

Monitoring Protocol

Perhaps the most complex part of developing a monitoring plan is specifying the protocols for each parameter and for each specific attribute. For some attributes, protocols can be relatively simple, but for others the level of detail and related considerations can be substantial. Some common protocols include:

- specification of methods and geographic extent of measurements,
- identification of monitoring period and frequency,
- design of monitoring forms, and
- a description of data-analysis techniques.

For a comprehensive review of monitoring protocols, refer to *Johnson, et al.*¹

Geographic Extent of Monitoring

It is important to identify the geographic extent of monitoring if a project includes risks of upstream and/or downstream impacts to both the channel and habitat processes. The longitudinal (upstream or downstream) extent of impacts is related to the scope of the project, the geomorphic setting and the specific technique and mitigation applied. As a general rule, a study reach that is 20 to 50 channel widths in length should be sufficient for monitoring impacts to channel form.² It is important to remember, however, that the longitudinal extent of monitoring is site-specific and should be based on specific project objectives.

Monitoring Duration and Frequency

Both the duration and frequency of monitoring are important components of a monitoring plan. A monitoring duration of three years should be considered a minimum for most bank-protection projects. A three-year monitoring period allows a project to be exposed to a range of flows and gives vegetation time to pass from the critical establishment phase to a more mature phase. However, changes in channel form may require a high flow or a series of high flows that have a low probability of occurrence during a three-year period. In other words, the geomorphic success of a project may not be properly evaluated until such flows occur. In addition, riparian vegetation may take many years of growth before its success in bank stabilization can be evaluated with any confidence. Any upstream and downstream project effects will likely require a series of high flows to before they become apparent. Therefore, the duration of monitoring may need to extend until some design flow event occurs, or until some vegetation density or percent cover is reached.

It may be appropriate to extend monitoring activities following certain flow events, for example within one month of any 10-year or greater flow. The primary determinants of a monitoring period should be project scope and project risk. Streambank-protection projects with numerous structural components that are subjected to considerable scrutiny or exposed to substantive risk should probably be monitored for five years. Monitoring these projects for a shorter period of time may fail to detect important indicators of project performance.

Monitoring frequency refers to how often monitoring activities will occur during any monitoring year and what time of year they should occur. In many cases, a single, annual monitoring effort is sufficient. The monitoring frequency may need to be based on the occurrence of specific flood events, especially when project risk is a factor, such as when a bank treatment is protecting a valuable resource. Alternatively, the monitoring frequency may be systematic during certain times of year. For example, it may be appropriate to conduct all habitat monitoring on one frequency interval that is tied to spawning schedules, while bank-protection elements and instream structures are monitored on another frequency interval that is tied to hydrologic sequences.

An economical solution to limited monitoring budgets is to adjust the schedule of the monitoring plan so that more intensive, quantitative data is collected during the critical first three years. After this initial period, the scope of monitoring can be reduced. For example, vegetative success of a biotechnical treatment may be sampled intensively for statistical analysis during the first three years. But after that time, a qualitative description of revegetation patterns may be sufficient to evaluate project success. After a few years, the objectives, scope and monitoring duration may change to reflect maintenance needs, rather than to achieve success criteria.

Collecting and Reporting of Monitoring Data

Collecting and reporting data is critical to a successful monitoring plan.

Baseline Data

Development of a monitoring plan should include specifying and assembling baseline data that will be referenced in subsequent monitoring. Project success can only be evaluated in reference to a baseline condition, which may be measured immediately before project construction and/or immediately upon completion. It may need to include historical information.³ Baseline data should correspond in format and detail to all subsequent data collected in order to measure success or impacts on both qualitative and quantitative levels. It is important to consider the timing of baseline conditions relative to annual hydrologic cycles and fish life cycles. Baseline-data collection and subsequent monitoring should be conducted at the same time of the year relative to fish life cycles and hydrologic conditions.

Baseline-data collection should include, but not be limited to,

- the establishment of permanent benchmarks (located away from areas of potential bank erosion);
- an as-built survey to document the project's configuration relative to permanent benchmarks;
- a summary of site hydrology (including location of the nearest gauging station) and values for critical flows that will be used to initiate monitoring events;
- documentation of aerial photography, summary of erosion history and any other geomorphic data pertinent to project location and design;
- documentation of preproject site and reach data pertaining to fish use, the riparian corridor, floodplain function and overall habitat condition; and
- documentation of any other conditions related to project or mitigation objectives.

Additionally, baseline data should be collected using the methods established in the monitoring protocol. It is crucial that qualitative and quantitative baseline-data collection be thorough and appropriate to provide a sound foundation for subsequent data collection and monitoring.³

Reporting Monitoring Data

Monitoring protocols should include a format for recording and presenting all monitoring data, including baseline data. All subsequent data from each monitoring period should follow the same format as that collected as baseline data and can then be evaluated with respect to baseline conditions.

Qualitative data is best represented as drawings or photo series with associated text. Drawings should all be digitized in consistent scale such that they can be reproduced as overlays or within a single drawing. Similarly, photo series should be taken from benchmarked photo points, with consistent use of lenses and orientation, so that photos can be viewed as overlays of chronological monitoring events. In some instances, qualitative data may be presented in tabular format, when the protocol requires judgment of quality, appearance or other nonvisual attributes.

Quantitative data should be presented in tabular format such that subsequent monitoring events can be readily compared from year to year and over the project life. Quantitative data input in a tabular format can be represented graphically. That way, each measured parameter can have a graphic representation that reveals change over time and indicates when critical thresholds for success or maintenance have been reached or achieved.

MONITORING-PLAN COMPONENTS

The following list can serve as a checklist of topics and details that should be included in any monitoring plan.

1. Statement of objectives:

- *project objectives*,
- *mitigation targets*, and
- *monitoring objectives*.

2. Baseline conditions:

- *geographic extent of monitoring*: Include a map illustrating the geographic extent of monitoring for baseline data and all surveying to be conducted during monitoring. Various monitoring components may have differing geographic boundaries.
- *baseline data*: A set of all data to be collected for all parameters to be measured as part of the monitoring program should be collected prior to conducting the project if possible and, at a minimum, immediately upon completion. Baseline data may include only as-built information if it is impractical or unnecessary to measure success relative to pre-existing conditions.
- *permanent reference points*: The monitoring plan should list any requirements regarding permanent or temporary benchmarks linked to monitoring activities, such as photo documentation, channel cross sections, vegetation transects, groundwater wells and photo points.

3. Monitoring protocol:

- *personnel qualifications*: The monitoring plan should specify the required experience level for personnel involved in monitoring data collection and analysis and the preparation of the monitoring report. This is essential for any monitoring activities sent out to bid.
- *maps/plan sheets/drawings*: The monitoring plan should specify the need for drawings and associated information such as the position of bank-protection measures, planting zones, cross sections, photo points and benchmarks.
- *description of measurement techniques*: A description should be included of specific techniques and methods for each parameter to be measured. Techniques and methods may include specific equipment and personnel necessary to acquire accurate and consistent data.

4. Monitoring schedule:

- *frequency*: Frequency may vary over time and may be sequenced according to calendar dates or scheduled relative to specific flow events.
- *duration*: The duration of the monitoring may be established according to calendar dates, or may be dependent upon achieving specific success criteria.
- *submittal dates*: Include submittal dates for all progress reports and final monitoring reports.

5. Reporting of monitoring data: The plan should specify:

- to whom copies of the monitoring report (s) should be submitted;
- what the monitoring report format should be; and
- what, if any, related data-presentation requirements may be involved.

6. Maintenance: The plan should specify what criteria or thresholds will initiate maintenance activities for all project components where it is appropriate.

MONITORING EXPERIMENTAL TECHNIQUES

New approaches to streambank protection continually evolve. Established protection methods, such as riprap, have well-documented design guidelines that result in high levels of protecting streambanks. However, standard design guidelines are lacking for many new types of bank-protection techniques. Comprehensive monitoring is important in order to assess new and experimental approaches and should focus on evaluating projects relative to their design criteria and the designs themselves so that future projects will be even more effective. It is essential that project objectives, designs, construction, mitigation and monitoring be integrated so that monitoring results educate practitioners about all known aspects of bank protection.

Monitoring activities should be designed to evaluate the performance of the treatment relative to specific criteria in addition to the overall objectives of the treatment. Because these criteria consist of measurable attributes, the monitoring plan can include methods for measuring these specific attributes to evaluate the success of the design and implementation, as separate from project objectives.

REFERENCES

- 1 Johnson, D. H., N. Pittman, E. Wilder, J. A. Silver, R. W. Plotnikoff, B. C. Mason, K. K. Jones, P. Roger, T. A. O'Neil and C. Barrett. 2001. Inventory and Monitoring of Salmon Habitat in the Pacific Northwest - Directory and Synthesis of Protocols for Management/Research and Volunteers in Washington, Oregon, Idaho, Montana, and British Columbia. Washington Department of Fish and Wildlife, Olympia, WA.
- 2 Kondolf, G. M. and E. R. Micheli. 1995. Evaluating stream restoration projects. *Environmental Management*. 19(1): 1-15.
- 3 Kondolf, G. M. 1995. Five elements for effective evaluation of stream restoration. *Restoration Ecology*. 3(2): 133-136.
- 4 Elzynga, C. L., D. Salzer and J. Willoughby. 1998. Measuring and Monitoring Plant Populations. Technical Reference 1730-1. Bureau of Land Management National Business Center, Denver, CO. 492 pp.

OTHER REFERENCES:

Ayers Associates. 1996. Supplement No. 8A to Design Memorandum No. 2. Sacramento River Bank Protection Project, Sacramento River and Tributaries, Lower American River, California. For U. S. Army Corps of Engineers and the state of California. Contract DACW05-940063. 118 pp.

Brittain, J. E. et al. 1992. Improvement of fish habitat in a Norwegian river channelization scheme. *Regulated Rivers: Research and Management*. 8: 189-194.

Cobb, D. G. et al. 1992. Effects of discharge and substrate stability on density and species composition of stream insects. *Canadian Journal of Fisheries and Aquatic Sciences*. 49: 1788-1795.

Duff, D.A. 1988. Indexed Bibliography on Stream Habitat Improvement. U.S. Department of Agriculture Forest Service, Intermountain Region, Ogden, UT.

Faurot, M.W. 1989. Habitat Utilization by Juvenile Pink and Chum Salmon in Upper Resurrection Bay, Alaska. Final Technical Report EL-89-17. U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS.

Groot, C. and L. Margolis. 1991. Pacific Salmon Life Histories. Department of Fisheries and Oceans, Pacific Biological Station, Nanaimo, BC, Canada. 563 pp.

Hynson, J. R. et al. 1985. Environmental Features for Streamside Levee Projects. Technical Report E-85-7. U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS.

Jones and Stokes Associates, Inc. 1996. Adopted Final Environmental Assessment and Initial Study of Streambank Protection at River Park - Lower American River. For the U.S. Army Corps of Engineers and the state of California.

Keown, M. P. 1983. Streambank Protection Guidelines for Landowners and Local Governments. U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS.

King County Department of Public Works, Surface Water Management. 1993. Guidelines for Bank Stabilization Projects in the Riverine Environments of King County. Seattle, WA.

Knight, S. S. and C. M. Cooper. 1991. Effects of bank protection on stream fishes. In: 5th Federal Inter-agency Sediment Conference, Las Vegas, NV. pp. 118-124.

Marcus, M. D., M. K. Young, L. E. Noel and B. A. Mullan. 1988. Salmonid-Habitat Relationships in the Western United States: A Review and Indexed Bibliography. U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, Ft. Collins, CO.

McMahon, T. E. 1983. Habitat Suitability Index Models: Coho Salmon. Report No. FWS/OBS-82/10.49. U.S. Fish and Wildlife Service, Habitat Evaluation Procedures Group.

McMahon, T. E. and G. F. Hartman. 1989. Influence of cover complexity and current velocity on winter habitat use by juvenile coho salmon (*O. kisutch*). Canadian Journal of Fisheries and Aquatic Sciences. 46: 1551-1557.